APPENDIX A

STORMWATER MANAGEMENT DESIGN CHARTS AND TABLES

TABLE A-1
IDF REGION 2DESIGN STORM RAINFALL

TABLE A-2
RUNOFF CURVE NUMBERS
(FROM NRCS (SCS) TR-55)

TABLE A-3
RATIONAL RUNOFF COEFFICIENTS
(ARON CURVES)

TABLE A-4
RATIONAL RUNOFF COEFFICIENTS
(RAWLS, WONG, McCUEN)

TABLE A-5
MANNING ROUGHNESS COEFFICIENTS
FOR OPEN CHANNELS AND MANNING N VALUES FOR SHEET FLOW

TABLE A-6
MANNING ROUGHNESS COEFFICIENTS
FOR PIPES

TABLE A-7
PERMISSIBLE VELOCITIES FOR CHANNELS

TABLE A-8
SOILS IDENTIFIED IN THE CENTRE COUNTY SOIL SURVEY
AS ON FLOOD PLAINS OR ON TERRACES ABOVE FLOOD PLAINS

TABLE A-1
IDF REGION 2 DESIGN STORM RAINFALL

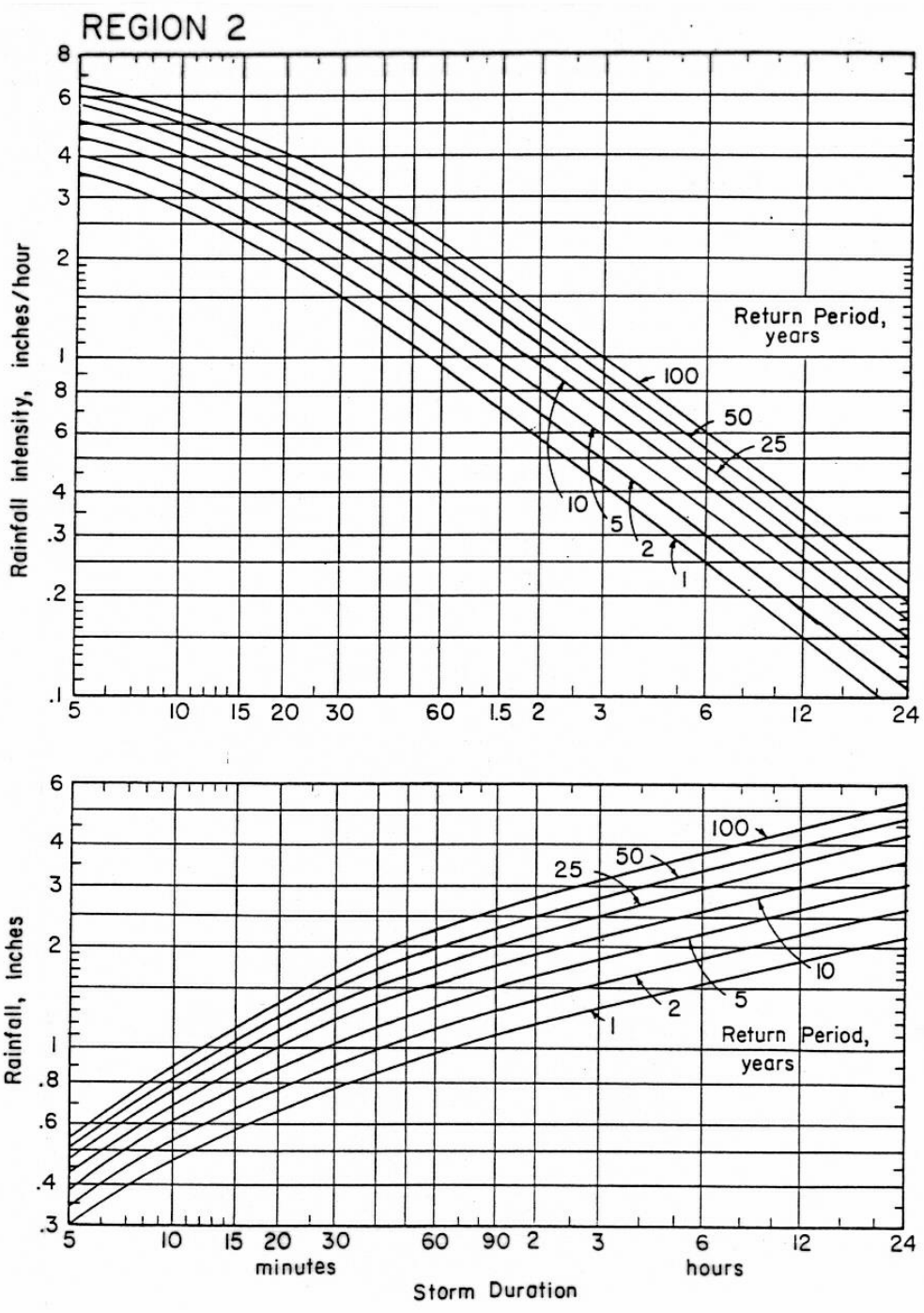

TABLE A-2
RUNOFF CURVE NUMBERS
(FROM NRCS (SCS) TR-55)

TR-55

Cover Description Land/Use Cover Type	Average Imperviousness (percent)	Curve Numbers For Hydrologic Soil Group A	B	C	D
Open space (lawns, parks, golf courses, cemeteries, etc.):					
Good condition (grass cover greater than 75%	n/a[a]	39	61	74	80
Impervious areas:					
Paved parking lots, roofs, driveways, etc. (excluding right-of-way)	n/a	98	98	98	98
Streets and roads:					
Paved; curbs and storm sewers (excluding right-of-way)	n/a	98	98	98	98
Paved; open ditches (including right-of-way)	n/a	98	98	98	98
Gravel (including right-of-way)		76	85	89	91
Urban Districts:					
Commercial and business	85	89	92	94	95
Industrial	72	81	88	91	93
Residential Districts by average lot size:					
1/8 acre or less (town houses)	65	77	85	90	92
1/4 acre	38	61	75	83	87
1/3 acre	30	57	72	81	86
1/2 acre	25	54	70	80	85
1 acre	20	51	68	79	84
2 acres	12	46	65	77	82
Woods:	n/a	30	55	71	77
Brush:		35	56	70	77
Meadow: (In good condition)		30	58	71	78

[a] Not applicable

Source: United States Department of Agriculture, Soil Conversation Service, Engineering Division, 1986, "Urban Hydrology for Small Watersheds," Technical Release 55, Washington, DC.

TABLE A-3
RATIONAL RUNOFF COEFFICIENTS
(ARON CURVES)

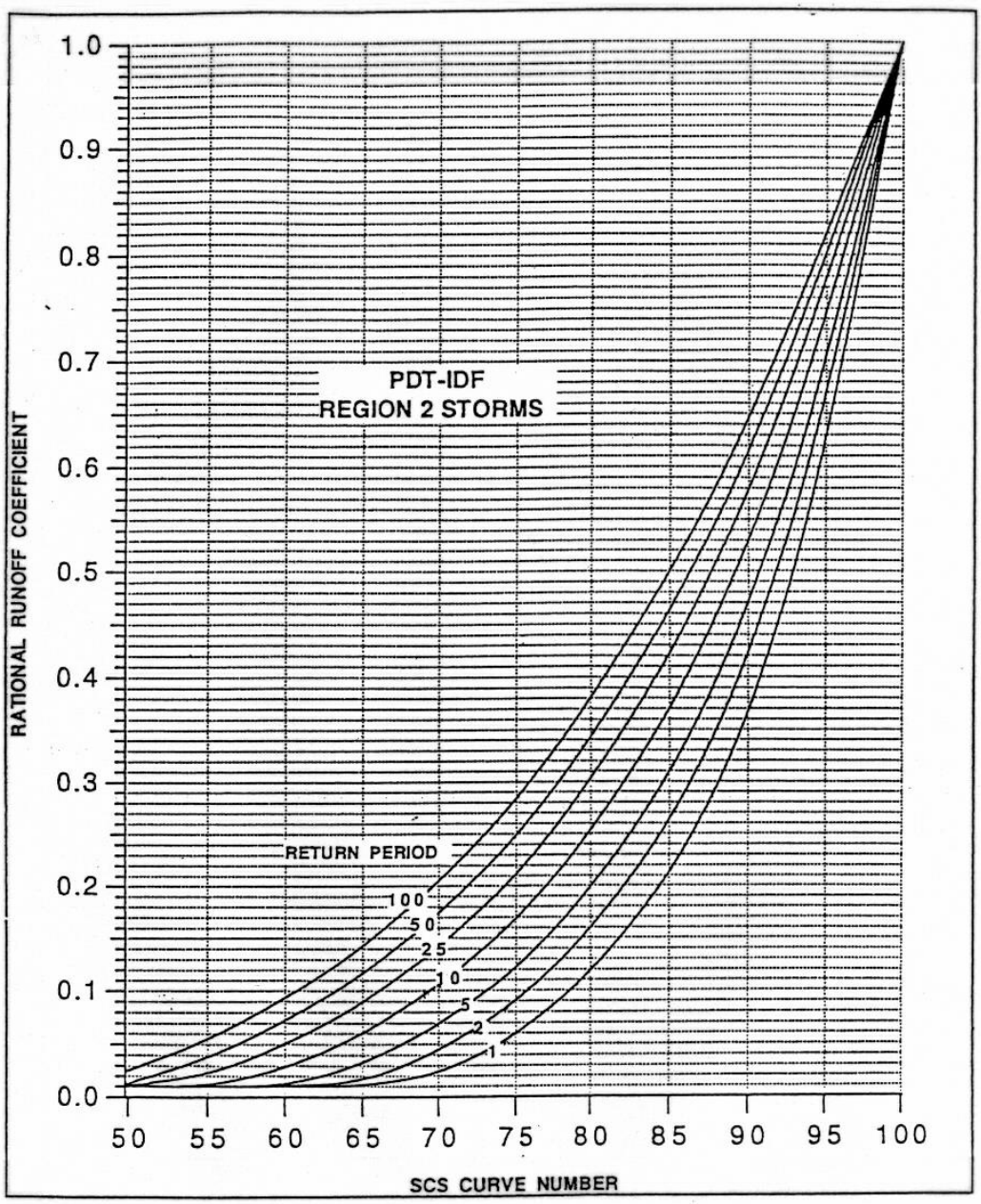

TABLE A-4
RATIONAL RUNOFF COEFFICIENTS
(RAWLS, WONG, McCUEN)

Runoff Coefficients for the Rational Formula
By Hydrologic Soil Group and Overland Slope (%)

	A			B			C			D		
Land Use	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+	0-2%	2-6%	6%+
Cultivated Land	0.08[a] 0.14[b]	0.13 0.18	0.16 0.22	0.11 0.16	0.15 0.21	0.21 0.28	0.14 0.20	0.19 0.25	0.26 0.34	0.18 0.24	0.23 0.29	0.31 0.41
Pasture	0.12 0.15	0.20 0.25	0.30 0.37	0.18 0.23	0.28 0.34	0.37 0.45	0.24 0.30	0.34 0.42	0.44 0.52	0.30 0.37	0.40 0.50	0.50 0.62
Meadow	0.10 0.14	0.16 0.22	0.25 0.30	0.14 0.20	0.22 0.28	0.30 0.37	0.20 0.26	0.28 0.35	0.36 0.44	0.24 0.30	0.30 0.40	0.40 0.50
Forest	0.05 0.08	0.08 0.11	0.11 0.14	0.08 0.10	0.11 0.14	0.14 0.18	0.10 0.12	0.13 0.16	0.16 0.20	0.12 0.15	0.16 0.20	0.20 0.25
Residential Lot Size 1/8 Acre	0.25 0.33	0.28 0.37	0.31 0.40	0.27 0.35	0.30 0.39	0.35 0.44	0.30 0.38	0.33 0.42	0.38 0.49	0.33 0.41	0.36 0.45	0.42 0.54
Lot Size 1/4 Acre	0.22 0.30	0.26 0.34	0.29 0.37	0.24 0.33	0.29 0.37	0.33 0.42	0.27 0.36	0.31 0.40	0.36 0.47	0.30 0.38	0.34 0.42	0.40 0.52
Lot Size 1/3 Acre	0.19 0.28	0.23 0.32	0.26 0.35	0.22 0.30	0.26 0.35	0.30 0.39	0.25 0.33	0.29 0.38	0.34 0.45	0.28 0.36	0.32 0.40	0.39 0.50
Lot Size 1/2 Acre	0.16 0.25	0.20 0.29	0.24 0.32	0.19 0.28	0.23 0.32	0.28 0.36	0.22 0.31	0.27 0.35	0.32 0.42	0.26 0.34	0.30 0.38	0.37 0.48
Lot Size 1 Acre	0.14 0.22	0.19 0.26	0.22 0.29	0.17 0.24	0.21 0.28	0.26 0.34	0.20 0.28	0.25 0.32	0.31 0.40	0.24 0.31	0.29 0.35	0.35 0.46
Industrial	0.67 0.85	0.68 0.85	0.68 0.86	0.68 0.85	0.68 0.86	0.69 0.86	0.68 0.86	0.69 0.86	0.69 0.87	0.69 0.86	0.69 0.86	0.70 0.88
Commercial	0.71 0.88	0.71 0.88	0.72 0.89	0.71 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.89	0.72 0.90	0.72 0.89	0.72 0.89	0.72 0.90
Streets	0.70 0.76	0.71 0.77	0.72 0.79	0.71 0.80	0.72 0.82	0.74 0.84	0.72 0.84	0.73 0.85	0.76 0.89	0.73 0.89	0.75 0.91	0.78 0.95
Open Space	0.05 0.11	0.10 0.16	0.14 0.20	0.08 0.14	0.13 0.19	0.19 0.26	0.12 0.18	0.17 0.23	0.24 0.32	0.16 0.22	0.21 0.27	0.28 0.39
Parking	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97	0.85 0.95	0.86 0.96	0.87 0.97

[a] Runoff coefficients for storm recurrence intervals less than 25 years.
[b] Runoff coefficients for storm recurrence intervals of 25 years or more.

Source: Rawls, W.J., S.L. Wong and R.H. McCuen, 1981, "Comparison of Urban Flood Frequency Procedures," Preliminary Draft, U.S. Department of Agriculture, Soil Conservation Service, Beltsville, MD.

TABLE A-5
MANNING ROUGHNESS COEFFICIENTS
FOR OPEN CHANNELS AND MANNING N VALUES FOR SHEET FLOW

	Manning's n range
I. Closed conduits:	
A. Concrete pipe	0.011-0.013
B. Corrugated-metal pipe or pipe arch:	
1. 2 1/2 by 1/2 inch corrugation (riveted) pipe:	
a. Plain or fully coated	0.024
b. Paved invert (range values are for 25 and 50 percent of circumference paved):	
(1) Flow full depth	0.021-0.018
(2) Flow 0.8 depth	0.021-0.016
(3) Flow 0.6 depth	0.019-0.013
2. 6 by 2-inch corrugation (field bolted)	0.030
C. Cast-iron pipe, uncoated	0.013
D. Steel pipe	0.009-0.011
E. Monolithic concrete:	
1. Wood forms, rough	0.015-0.017
2. Wood forms, smooth	0.012-0.014
3. Steel forms	0.012-0.013
F. Cemented rubble masonry walls:	
1. Concrete floor and top	0.017-0.022
2. Natural floor	0.019-0.025
II. Open channels, lined (straight alignment):	
A. Concrete, with surfaces as indicated:	
1. Formed, no finish	0.013-0.017
2. Trowel finish	0.012-0.014
3. Float finish	0.013-0.015
4. Float finish, some gravel on bottom	0.015-0.017
5. Gunite, good section	0.016-0.019
6. Gunite, wavy section	0.018-0.022
B. Concrete, bottom float finished, sides as indicated:	
1. Dressed stone in mortar	0.015-0.017
2. Random stone in mortar	0.017-0.020
3. Cement rubble masonry	0.020-0.025
4. Cement rubble masonry, plastered	0.016-0.020
5. Dry rubble (riprap)	0.020-0.030
C. Gravel bottom, sides as indicated:	
1. Formed concrete	0.017-0.020
2. Random stone in mortar	0.020-0.023
3. Dry rubble (riprap)	0.023-0.033
D. Asphalt	
1. Smooth	0.013
2. Rough	0.016
E. Concrete-lined excavated rock:	
1. Good section	0.017-0.020
2. Irregular section	0.022-0.027

	Manning's n range
III. Open channels, excavated (straight alignment, natural lining):	
A. Earth, uniform section:	
1. Clean, recently completed	0.016-0.018
2. Clean, after weathering	0.018-0.020
3. With short grass, few weeds	0.022-0.027
4. In gravely soil, uniform section, clean	0.022-0.025
B. Earth, fairly uniform section:	
1. No vegetation	0.022-0.025
2. Grass, some weeds	0.025-0.030
3. Dense weeds or aquatic plants in deep channels	0.030-0.035
4. Sides clean, gravel bottom	0.025-0.030
5. Sides clean, cobble bottom	0.030-0.040
C. Dragline excavated or dredged:	
1. No vegetation	0.028-0.033
2. Light brush on banks	0.035-0.050
D. Rock:	
1. Based on design section	0.035
2. Based on actual mean section:	
a. Smooth and uniform	0.035-0.040
b. Jagged and irregular	0.040-0.045
E. Channels not maintained, weeds and brush uncut:	
1. Dense weeks, high as flow depth	0.080-0.120
2. Clean bottom, brush on sides	0.050-0.080
3. Clean bottom, brush on sides, highest stage of flow	0.070-0.110
4. Dense brush, high stage	0.100-0.140
IV. Channels and swales w/maintained Vegetation (values shown are for velocities of 2 & 6 f.p.s.):	
A. Depth of flow up to 0.7 foot:	
1. Bermudagrass, Kentucky bluegrass, buffalograss	
a. Mowed to 2 inches	0.045-0.070
b. Length 4-6 inches	0.050-0.090
2. Good stand, any grass:	
a. Length about 12 inches	0.090-0.180
b. Length about 24 inches	0.150-0.300
3. Fair stand, any grass:	
a. Length about 12 inches	0.080-0.140
b. Length about 24 inches	0.130-0.250
B. Depth of flow 0.7-1.5 feet:	
1. Bermudagrass, Kentucky bluegrass, buffalograss:	
a. Mowed to 2 inches	0.035-0.050
b. Length 4 to 6 inches	0.040-0.060
2. Good stand, any grass:	
a. Length about 12 inches	0.070-0.120
b. Length about 24 inches	0.100-0.200
3. Fair stand, any grass:	
a. Length about 12 inches	0.060-0.100
b. Length about 24 inches	0.090-0.170

	Manning's n range
V. Street and expressway gutters:	
A. Concrete gutter, troweled finish	0.012
B. Asphalt pavement:	
1. Smooth texture	0.013
2. Rough texture	0.016
C. Concrete gutter with asphalt pavement	
1. Smooth	0.013
2. Rough	0.015
D. Concrete pavement:	
1. Float finish	0.014
2. Broom finish	0.015
E. For gutters with small slope, where sediment may accumulate, increase above values of x by	0.002
VI. Natural stream channels:	
A. Minor streams (surface width at flood stage less than 100 feet):	
1. Fairly regular section:	
a. Some grass & weeds, little or no brush	0.030-0.035
b. Dense growth of weeks, depth of flow materially greater than weed height	0.035-0.050
c. Some weeks, light brush on banks	0.035-0.050
d. Some weeks, heavy brush on banks	0.050-0.070
e. Some weeks, dense willows on banks	0.060-0.080
f. For trees within channel with branches submerged at high stage, increase all above values by	0.010-0.020
2. Irregular sections, with pools, slight channel meander; increase given in 1 a-e about	0.010-0.020
3. Mountain streams, no vegetation in channel, banks usually steep, trees and brush along banks submerged at high stage	
a. Bottom of gravel, cobbles and few boulders	0.040-0.050
b. Bottom of cobbles, with large boulders	0.050-0.070
B. Floodplains (adjacent to natural streams):	
1. Pasture, no brush:	
a. Short grass	0.030-0.035
b. High grass	0.035-0.050
2. Cultivated areas:	
a. No crop	0.030-0.040
b. Mature row crops	0.035-0.045
c. Mature field crops	0.040-0.050
3. Heavy weeds, scattered brush	0.050-0.070
4. Light brush and trees:	
a. Winter	0.050-0.060
b. Summer	0.060-0.080
5. Medium to dense brush:	
a. Winter	0.070-0.110
b. Summer	0.100-0.160
6. Dense willows, summer, not bent over by current	0.150-0.200
7. Cleared land w/tree stumps, 100-150 per acre:	
a. No sprouts	0.040-0.050
b. With heavy growth of sprouts	0.060-0.080
8. Heavy stand of timber, a few down trees, little undergrowth:	
a. Flood depth below branches	0.100-0.120
b. Flood depth reaches branches	0.120-0.160
C. Major streams (surface width at flood stage more than 100 feet): Roughness coefficient is usually less than for minor streams of less effective resistance offered by irregular banks or vegetation on banks. Values of n may be somewhat reduced. Follows recommendation in publication cited if possible. The value of n for larger streams of most regular section, with no boulders or brush, may be in the range of	0.028-0.033

MANNING'S ROUGHNESS COEFFICIENTS FOR SHEET FLOW

SURFACE DESCRIPTION	n^1
Smooth surfaces (concrete, asphalt, gravel, or bare soil)	0.011
Fallow (no residue)	0.05
Cultivated soils:	
Residue cover 20%	0.06
Residue cover 20%	0.17
Grass:	
Short grass prairie	0.15
Dense grasses	0.24
Bermudagrass	0.41
Range (natural)	0.13
Woods:	
Light underbrush	0.40
Dense underbrush	0.80

Source: Chow, V.T., 1959, "Open Channel Hydraulics," McGraw Hill, New York.

TABLE A-6
MANNING ROUGHNESS COEFFICIENTS FOR PIPES

Description	"n"
Smooth-roll plastic pipe	0.011
Concrete pipe	0.012
Smooth-lined corrugated metal pipe	0.012
Corrugated plastic pipe	0.024
Annular corrugated steel and aluminum Alloy pipe (plain or polymer coated) 2 2/3" x 1/2' corrugations 3" x 1" corrugations 5" x 1" corrugations 6" x 2" corrugations	 0.024 0.027 0.025 0.033
Helically corrugated steel and aluminum Alloy pipe (plain or polymer coated) 3" x 1", 5" x 1" or 6" x 2" corrugations	0.024
Helically corrugated steel and aluminum Alloy pipe (plain or polymer coated) 2 2/3" x 1/2" corrugations a. lower coefficients● 18" diameter 24" diameter 36" diameter 48" diameter 60" diameter or larger b. Higher coefficients▲	 0.014 0.016 0.019 0.020 0.021 0.024
Annular or Hhlically corrugated steel or aluminum alloy pipe arches or other on-circular conduit (plain or polymer coated)	0.024
Vitrified clay pipe	0.012
Ductile iron pipe	0.013

●Use the lower coefficient if any one of the following conditions apply:

a. A storm pipe longer than 20 diameters, which directly or indirectly connects to an inlet or manhole, located in swales adjacent to shoulders in cut areas, shoulders in cut areas or depressed medians.

b. A storm pipe which is specially designed to perform under pressure.

▲Use the higher coefficient if any one of the following conditions apply:

a. A storm pipe which directly or indirectly connects to an inlet or manhole located in highway pavement sections or adjacent to curb or concrete median barrier.

b. A storm pipe which is shorter than 20 diameters long.

c. A storm pipe which is partly lined helically corrugated metal pipe.

In considering each factor more critical, judgement is necessary if it is kept in mind that any condition that causes turbulence and retards flow results in a greater value of "n."

Outlet velocity for bituminous paved invert shall be determined based on a 25% reduction in Manning's roughness coefficient, "n."

Source: Pennsylvania Department of Transportation Design Manual, Part 2, January 1990.

TABLE A-7
PERMISSIBLE VELOCITIES FOR CHANNELS

Maximum Permissible Velocities in Bare Earth Channels -For Straight Channels where slope < .02 ft/ft

Soil Materials	n*	Clear Water (V fps)	Water Transporting Colloidal Silts (V fps)
Fine sand, noncolloidal	.020	1.50	2.50
Sandy loam, noncolloidal	.020	1.75	2.50
Silt loam, noncolloidal	.020	2.00	3.00
Alluvial silts, noncolloidal	.020	2.00	3.50
Ordinary firm loam	.020	2.50	3.50
Stiff clay, very colloidal	.025	3.75	5.00
Alluvial silts, colloidal	.025	3.75	5.00
Shales and hardpan	.025	6.00	6.00
Fine Gravel	.020	2.50	5.00
Graded loam - cobbles (when noncolloidal)	.030	3.75	5.00
Graded silt - cobbles (when noncolloidal)	.030	4.00	5.50
Coarse gravel noncolloidal	.025	4.00	6.00
Cobbles and shingles	.035	5.00	5.50

* Listed n values assume good to excellent construction techniques which produce uniform channel dimensions. Values should be adjusted, by use of SCS Engineering Handbook #5, Supplement B, for other construction conditions.

TABLE A-5.2 Maximum Permissible Velocities for Channels Lines with Vegetation

Cover	Slope Range Percent	Permissible Velocity ft/sec. Erosion[1] Resistant Soil	Easily[2] Eroded Soil
Kentucky Bluegrass Tall Fescue	< 5 5-10 > 10	7[3] 6[3] 5	5 4 3
Grass Mixture Reed Canarygrass	< 5 5-10	5 4	4 3
Sericea Lespedeza Weeping Lovegrass Redtop Red Fescue	< 5	3.5	2.5
Annuals temporary cover only Sudangrass	< 5	3.5	2.5

[1] Cohesive (clayey) fine grain soils and coarse grain soils with a plasticity index of 10 to 40 (CL, CH, SC, & GC).
[2] Soils that do not meet the requirements for erosion resistant soils.
[3] Use velocities exceeding 5 ft./sec. only where good cover and proper maintenance can be obtained.

TABLE A-8
SOILS IDENTIFIED IN THE CENTRE COUNTY SOIL SURVEY
AS ON FLOOD PLAINS OR ON TERRACES ABOVE FLOOD PLAINS

Allegheny Series	Allegheny silt loam (AlB)
Atkins Series	Atkins silt loam (At)
Basher Series	Basher loam (Ba)
Chagrin Series	Chagrin Soils (Ch)
Dunning Series	Dunning silty clay loam (Du)
Lindside Series	Lindside soils (Lx)
Melvin Series	Melvin silt loam (Mm)
Monongahela Series	Monongahela silt loam (MoB)
Philo Series	Philo loam (Ph), Philo and Atkins very stony soils (Pk)
Pope Series	Pope soils (Po)
Purdy Series	Purdy silt loam (Pu)
Tyler Series	Tyler silt loam (Ty)

APPENDIX B

WATERSHED MAPS

Sensitive Land Areas for Well Head Protection Data Source

Well Fields 1 and 3: Harter and Thomas Well Fields

Municipality: Harris, Ferguson, and College Townships
Well Owner: State College Water Authority
Includes wells: H7, H8, H11, H14, H22, H25
Protection Area: One-year zone of contribution
Source: Nittany Geoscience, February 1992, Figure 4

Well Field 5

Municipality: Ferguson Township
Well Owner: State College Water Authority
Includes wells: F55, F57
Protection Area: One-year zone of contribution
Source: Nittany Geoscience, February 1992, Figure 4

Well Field 6

Municipality: Benner and Patton Townships
Well Owner: State College Water Authority
Includes wells: B62, B63, B64, B65
Protection Area: One-year zone of contribution + direct upslope lands
Source: Nittany Geoscience, February 1992, Figure 4

PSU Golf Course Well Field

Municipality: Ferguson Township and the Borough of State College
Well Owner: Penn State University
Includes wells: PS28A, PS 37
Protection Area: One-year zone of contribution
Source: Nittany Geoscience, January, Figure 5

PSU Big Hollow Well Field

Municipality: Patton, Ferguson, and College Townships
Well Owner: Penn State University
Includes wells: PS2, PS14, PS16, PS17, PS24, PS26
Protection Area: One-year zone of contribution
Source: Nittany Geoscience, January, Figure 5

PSU Houserville Well Field

Municipality: Ferguson Township
Well Owner: Penn State University
Includes wells: PS33, PS 34, PS35
Protection Area: One-year zone of contribution
Source: Nittany Geoscience, January, Figure 5

Existing Well and Spring

Municipality: Ferguson Township
Well Owner: State College Water Authority
Includes wells: F3
Protection Area: 400' Radius + direct upslope lands

Ridgemont Wells

Municipality: Patton Township
Well Owner: Ridgemont Water Authority
Includes wells: P1, P2
Protection Area: 400' Radius

Spring Creek Park, Lemont #4, Lemont #5,and Rogers Wells, and Bathgate Springs

Municipality: College Township
Well Owner: College Township Water Authority
Includes wells: C1, C2, C3, C4, C5
Protection Area: 400' Radius